Flare™

Global Shutter CMOS Camera Series

4KSDI

HD/3G-SDI

User's Manual

Revision 3.4

IO INDUSTRIES

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Established in 1991, IO Industries Inc. designs high performance digital imaging products for applications in manufacturing, research, vehicle-mounted systems, and video game content creation. Products include PC-based, standalone and peripheral DVR systems; and high speed CMOS area scan digital cameras.

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1 Introduction

The Flare 4KSDI CMOS area scan camera is designed for a broad range of applications including: medical, specialty broadcast and digital cinema, process monitoring and security. The SMPTE standard Serial Digital Interface (SDI) output allows for long, inexpensive cable lengths and provides easy connectivity to monitors, recorders and other broadcast or scientific equipment.

The following camera model is covered in this manual:

Model	Resolution	Color	Output Format
4KSDI	4096 x 2160	Bayer	HD/3G-SDI

Table 1. Covered Flare 4KSDI Model

1.1 Output Formats

The supported output formats for the 4KSDI model are shown in Table 2.

Interface	Image Format	Color/Bit Depth	Frame Rate (Hz)
Quad Link HD-SDI SMPTE ST 292	4096 x 2160	4:2:2 Y'Cb'Cr' 10-bit	23.98, 24, 25, 29.97, 30
	3840 x 2160	4:2:2 Y'Cb'Cr' 10-bit	23.98, 24, 25, 29.97, 30
Quad Link 3G-SDI SMPTE ST 425-A	4096 x 2160	4:2:2 Y'Cb'Cr' 10-bit	47.95, 48, 50, 59.94, 60
	4096 x 2160	4:4:4 R'G'B' 10-bit	23.98, 24, 25, 29.97, 30
	3840 x 2160	4:2:2 Y'Cb'Cr' 10-bit	50, 59.94, 60
	3840 x 2160	4:4:4 R'G'B' 10-bit	23.98, 24, 25, 29.97, 30
Dual Link 3G-SDI Level B SMPTE ST 372	4096 x 2160	4:2:2 Y'Cb'Cr' 10-bit	23.98, 24, 25, 29.97, 30
	3840 x 2160	4:2:2 Y'Cb'Cr' 10-bit	23.98, 24, 25, 29.97, 30

Table 2. Supported output formats

1.2 Camera Highlights

- Super 35 global shutter CMOS sensor
- Base ISO rating 300, adjustable up to 1200 (+12dB)
- Dynamic range: 12 stops
- Quadrant and 2SI (SMPTE 425-5) image mapping supported
- Quad-Link and Dual-Link output formats supported
- Raw output
- Optical Low Pass Filter (OLPF) and IR-Cut filter
- Color temperature presets, Auto White Balance (AWB) and Tracking AWB
- Color Correction Matrix (CCM) and Saturation
- Auto exposure and gain control
- Full image Gamma Lookup Table (LUT)
- Black Gamma LUT with level setting
- RGB LUT
- User programmable raw LUT
- Master pedestal adjustment
- Tri-level sync input
- Rugged aluminum case
- Interchangeable lens mounts: ARRI PL, Nikon F, passive and active Canon EF.
- RS-485 control with host application or handheld remote
- On Screen Display (OSD) menu overlay
- Digital gain up to 4x (+12 dB)
- Low power, 11W @ 12V

2 Remote Control

A handheld remote control can be used to control the Flare 4KSDI camera. The remote body is made from machined aluminum with a 9-button membrane keyboard making it extremely rugged and durable. On three sides of the remote there are 1/4"-20 (tripod) mounting holes and the bottom side has a 4-pin LEMO connector for power and communications.

Figure 1 shows the front view of the remote control, with a description of the button functions.

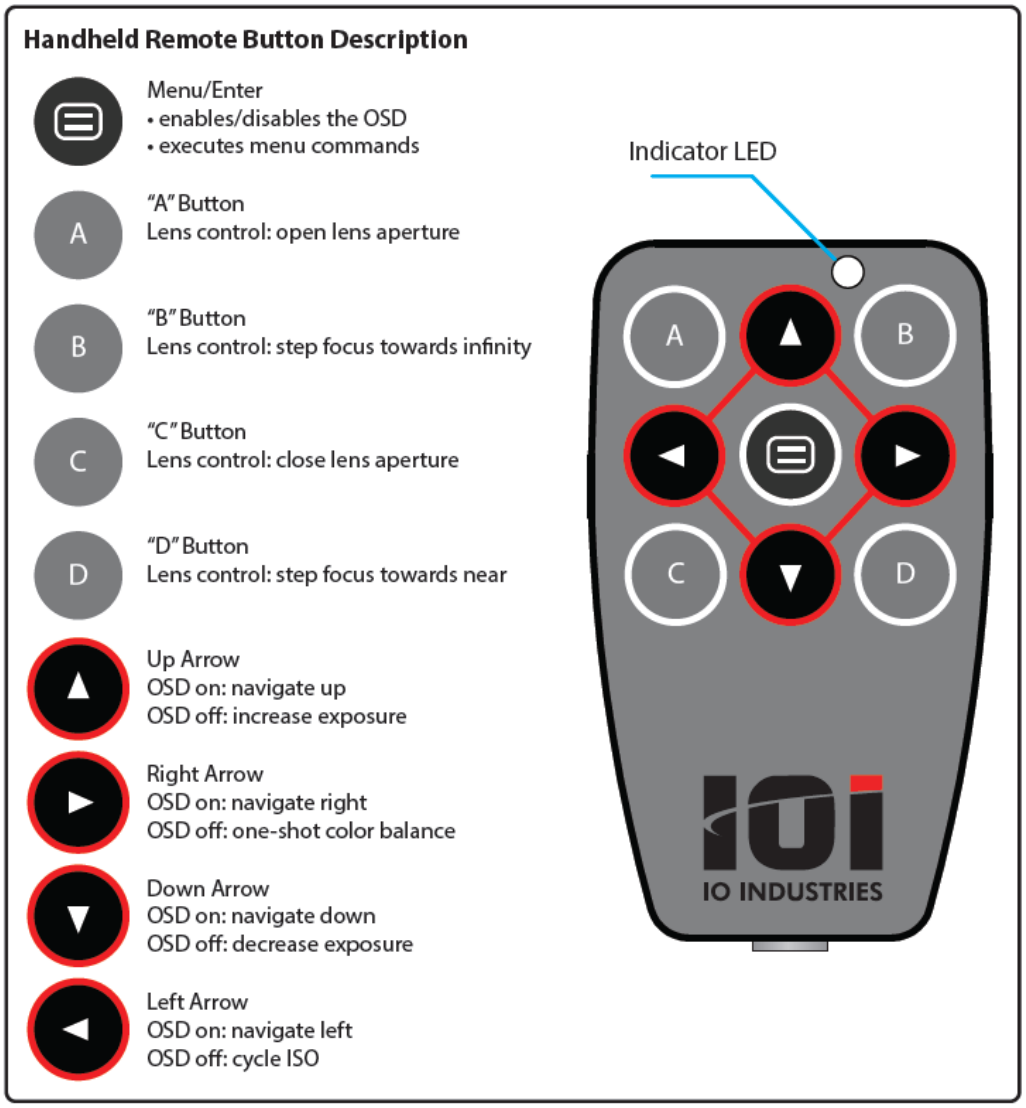

Figure 1. Remote control

The mechanical specifications are shown in Table 3.

Specification	Description
Size	62 mm (w) x 99.3 mm (h) x 17.5 mm (d)
Weight	150 g
Mounting Holes	3 x 1/4"-20 (tripod), top and sides
Power/Comm Connector	4-pin LEMO EGJ.0B.304-CLA Mating connector used on IO Industries cables: FGJ.0B.304-CLLD52Z

Table 3. Remote mechanical specifications

The pinout of the power connector is shown in Table 4.

Pin	Description
1	RS485-
2	RS485+
3	GND
4	10-19 V DC

Table 4. Remote power connector pinout

2.1 Getting Started

The On Screen Display (OSD) menu overlay is in the top left corner of the output images. In a quadrant readout format the menu is only present in the first quadrant, SDI output #1. When the camera is operating in a Dual Stream output the menu overlay is only on SDI outputs #1 and #2, while outputs #3 and #4 provide a clean output with no overlays.

Press the *Enter* button in the center of the remote to open the menu. The main menu is shown in Figure 2.

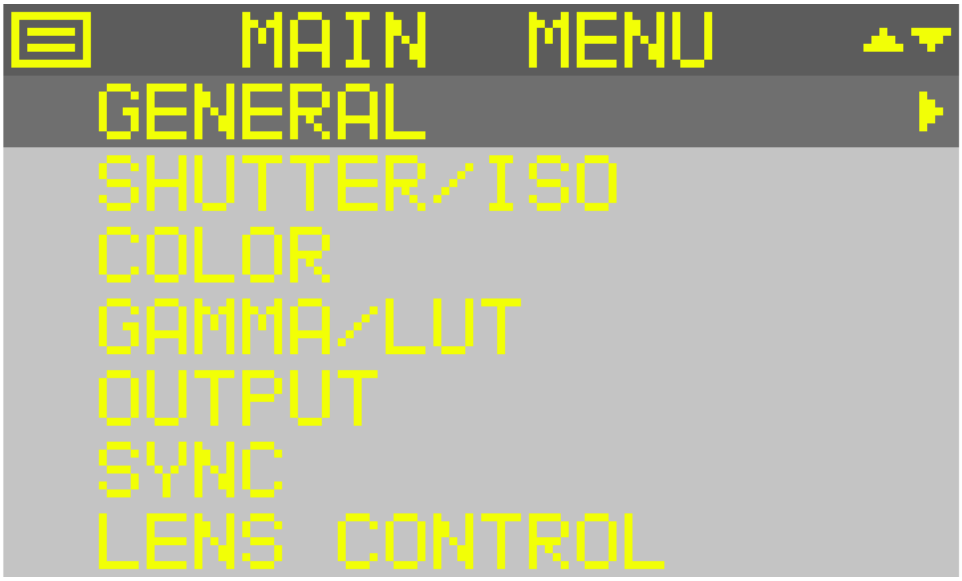

Figure 2. Main menu

The main menu is overlaid in the top left of the image, inside the safe action zone. The menu is alpha blended with the luma portion of the image for transparency. The top line or title line of the menu indicates whether the main menu or sub-menu is currently being displayed. The *Enter* button symbol is shown in the top left corner of the main menu to indicate how to exit the main menu. Press the *Enter* button to close the main menu.

The only features not available when using the remote control are renaming user sets and Look Up Tables (LUT), and loading custom or RGB LUTs into the camera. These features require the 4KSDI to be connected to a PC and can found in the Flare Control software.

Use the *Up* and *Down* scroll keys on the keypad to navigate the main menu, indicated by the up/down arrow in the top right corner of the menu.

The currently selected line is indicated by the mid grey level. The menu background is the lightest grey tone, and the title line is the darkest.

Press the *Right* scroll key to select a sub-menu.

2.2 Sub-Menus

While in the main menu press the *Right* scroll key to select a sub-menu. The *Shutter/ISO* sub-menu is shown in Figure 3.

Figure 3. Shutter/ISO sub-menu

The *Left* scroll button symbol is shown in the top left corner of any sub-menu to indicate how to return to the main menu. Press the *Left* scroll button to return to the main menu.

Use the *Up* and *Down* scroll keys on the keypad to navigate the selected sub-menu commands, indicated by the up/down arrow in the top right corner of the menu.

To select a command press the *Right* scroll key while that command is the active line (mid

grey tone line). If a command is not selectable the right arrow will not appear when the line is selected. For example changing the exposure angle is not possible when auto-exposure is enabled.

Figure 4 shows the Shutter/ISO sub-menu with the value command selected.

Figure 4. Shutter/ISO sub-menu with value command selected

When a command is selected the current setting is shown to the right of the sub-menu. Only the selected command line is displayed with yellow text and the rest of the sub-menu text is changed to a mid grey value. Use the *Up* and *Down* scroll keys to change the command parameter, indicated by the up/down arrows shown at the end of the parameter line.

When the lowest parameter value for the command is reached only the up arrow will be displayed, and when the highest parameter value is reached only the down arrow will be displayed. If there is only one option for the command neither the up nor down arrow will be shown.

To return to the sub-menu press the *Left* scroll key.

Some commands will change the parameter immediately, like the exposure angle shown in Figure 4. For commands that take longer to execute (video format) and those which present a list of available options to select (save to user set), the *Enter* key will be shown at the end of the parameter line.

The General sub-menu with the video format command selected is shown in Figure 5.

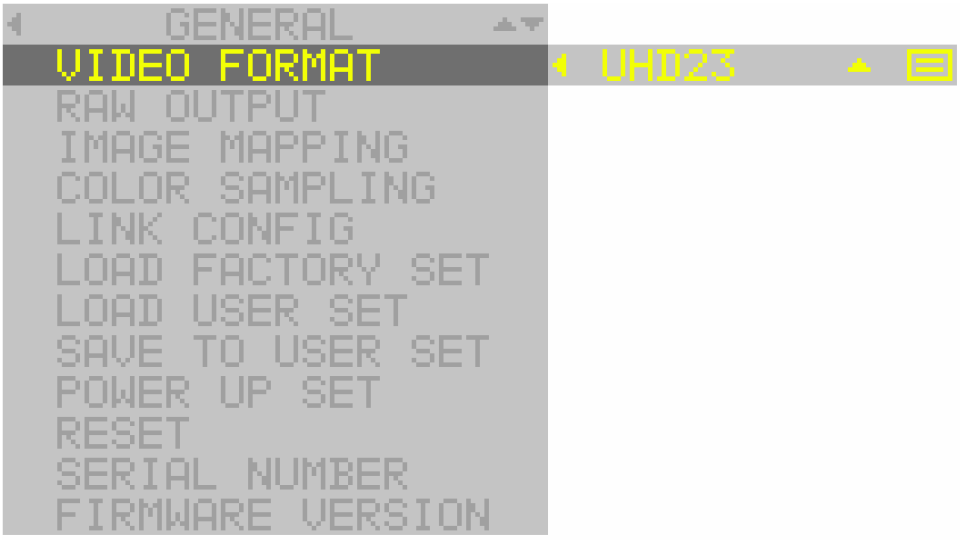

Figure 5. General sub-menu with video format command selected

For commands where the *Enter* key is shown at the end of the parameter line, scroll through the list of parameters using the *Up* and *Down* scroll keys and to set the desired parameter press the *Enter* button. After the command completes the on-screen menu will return to the sub-menu. To exit the parameter list for a command press the *Left* scroll key.

2.3 Command Protocol

The remote control uses a simple ASCII command protocol similar to the host RS-485 adapter. Below are some key points about the serial control:

- 8-bit, 115200 baud, 1 stop bit and no parity.
- All remote control commands start with a single apostrophe sign (27h) followed by a character in the range 30h-3Fh and finish with a carriage return (0Dh).
- When the remote control is first powered a discovery command of '0<CR> (27h, 30h, 0Dh) is repeated until any button is pressed or an ACK character (06h) is received from the camera. The status LED will blink during this process.

Table 5 shows the character values for each button on the membrane keyboard. Some advanced users can integrate these commands into other RS485 equipment to control Flare cameras.

Button	ASCII Character (hex value)	Button	ASCII Character (hex value)
Enter	5 (35h)	A	1 (31h)
Left Scroll	4 (34h)	A held	< (3Ch)
Right	6 (36h)	B	3 (33h)
Up	2 (32h)	B held	= (3Dh)
Up held	: (3Ah)	C	7 (37h)
Down	8 (38h)	C held	> (3Eh)
Down held	; (3Bh)	D	9 (39h)
		D held	? (3Fh)

Table 5. Keyboard ASCII command values

3 Host Control Utility

A utility is provided to control the Flare 4KSDI cameras using a USB to RS-485 adapter connected to a PC running 32-bit or 64-bit Windows (XP/2000/Vista/Win7) operating system. Other RS-485 adapters can be used, however contact IO Industries for a list of supported devices.

3.1 Installation

The control utility installer, **flare_sdi.exe** (or **flare_sdi_x64.exe)**, can be downloaded at the following URL: http://www.ioindustries.com/provideo/products/4ksdi_downloads.html.

Follow the steps below to install the application:

1. Extract the installers from the downloaded zip file.
2. Run flare_sdi.exe (or flare_sdi_x64.exe).
3. Press Next on the first screen, *Welcome to the Flare SDI Software Setup Wizard.*
4. Choose a destination folder for the install location. Use the Browse button to navigate the system for a location.
5. Choose which components to install on the *Choose Components* screen.
6. Press Install button.
7. Part way through a driver installer package for the USB to RS-485 cable adapter will also run. Follow the instructions.
8. Depending on the system a reboot may be necessary when the installation completes.

3.2 Component Setup

Once the control utility has been installed follow the steps below to setup the Flare 4KSDI camera system:

- Put lens on camera.
- Connect power supply or battery to camera.
- Connect coax cables to SDI output #1, #2, #3 and #4 and connect the other end of the cables to a monitor or recorder. Note only two cables are required in dual link mode.
- Plug USB to RS-485 control cable into PC (USB side), and connect other end of cable (DB9 or Lemo connector) to power cable extension connector.
- With the camera powered start host application, **flare_sdi_ctrl.exe**.

There are 7 main views to the control application, which are described in the following sections:

- General, Exposure/Gain, Color, Gamma/LUT, Output, Lens Control and Advanced

When the application starts all detected camera's serial numbers will be in the drop list at the top of application interface. A refresh button in the top left corner will force the application to re-search all available COM ports in the system for Flare SDI cameras.

Select the serial number of the camera to control in the drop list.

3.3 Slider Bar Control

Many parameters in the control utility are changed using a slider bar control. Use the mouse to move the slider bar to change values, while holding down the left mouse button. Once focus is on the slider bar the following keyboard options can also be used to change the setting:

- Left/right or up/down arrow keys for fine adjustment.
- Page Up/Down keys for coarse adjustment.
- Home and End keys to set value to min or max, respectively.

3.4 General View

The General control view is shown in Figure 6.

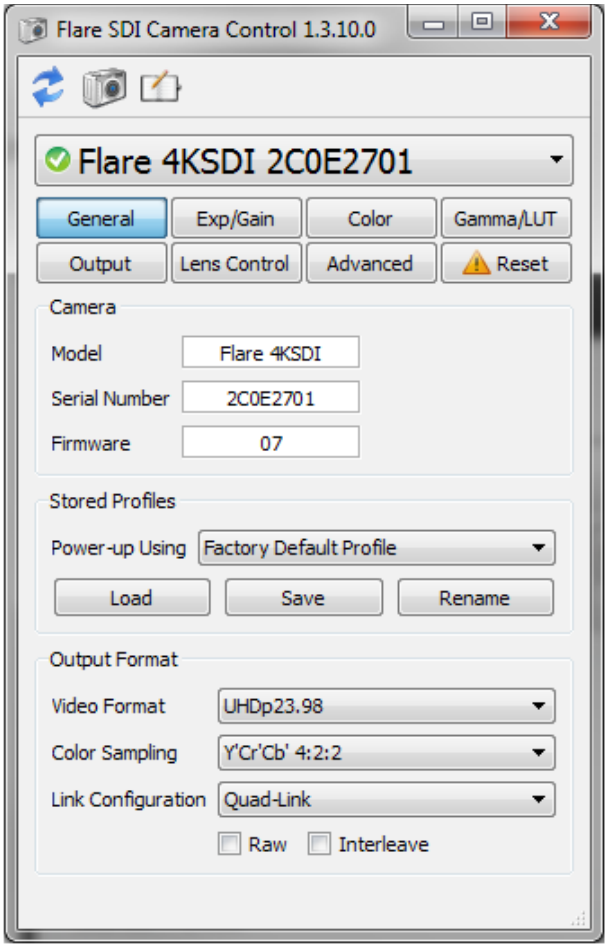

Figure 6. General view

3.4.1 Camera

The model, serial number and firmware version are shown in this section for the selected camera.

3.4.2 Stored Profiles

To change the power-up profile of the camera select one of the 8 user profiles or the factory profile in the drop down list.

To load a user set or the factory profile press the *Load* button. Select one of the 8 user set profiles or the factory profile in the drop down list.

To save the current camera settings to one of the 8 user profiles press the *Save* button. Select the profile from the drop list and press the *OK* button.

To rename one of the 8 user profiles press the *Rename* button. Select the profile to rename in the drop down list. Enter the new name for the profile, max 32 characters, and press *OK*.

Note only the first 16 characters of the user profile name will be shown in the OSD menu overlay.

3.4.3 Output Format

Use the *Video Format* drop down list to chose the output resolution and frame rate. The video format selection overrides the color sampling and link configuration options. For example if the current color sampling is set to R'G'B' 4:4:4 and the video mode is changed to UHD at 60Hz, the color sampling will automatically be switched to Y'Cb'Cr' 4:2:2.

For frame rates 30Hz or lower both 10-bit R'B'B 4:4:4 and Y'Cb'Cr' 4:2:2 color sampling are available. Only Y'Cb'Cr' 4:2:2 sampling is available for frame rates higher than 30Hz. Use

the *Color Sampling* drop down list to chose the sampling format.

Use the *Link Configuration* drop down list to choose between *Quad Link* and *Dual Link*. In the *Dual Link* configuration the four output streams are combined over two Level B 3G-SDI links in a dual stream format according to SMPTE ST 372. Only frame rates 30Hz or lower and Y'Cb'Cr 4:2:2 sampling are supported in the *Dual Link* configuration.

Use the *Raw* checkbox to enable a raw output, which bypasses the internal camera color data path. Note the raw output is automatically in the extended range (SMPTE 274M Section 8.7).

Use the *Interleave* checkbox to enable 2SI (SMPTE 425-5) image mapping. Leaving this checkbox un-checked means that quadrant based image mapping will be used.

3.5 Exposure/Gain View

The Exposure/Gain control view with *Fixed* exposure mode selected is shown in Figure 7.

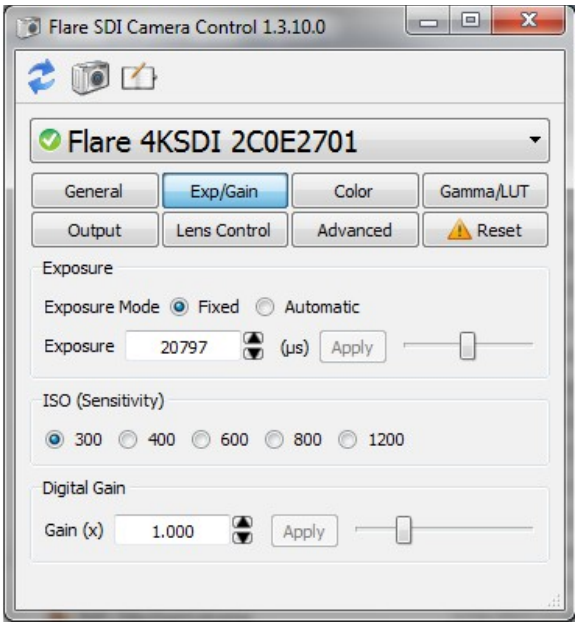

Figure 7. Exposure/Gain view

3.5.1 Exposure

Use the slider bar in the exposure section to set the exposure time, or enter the value and press the *Apply* button. Use the up/down arrows for fine adjustments to the exposure value.

The exposure section with *Automatic* exposure mode selected and *Auto Mode* set to *Exposure + Aperture + Digital Gain* is shown in Figure 8.

There are four modes of automatic exposure control:

- Exposure Only
- Exposure + Digital Gain
- Exposure + Aperture
- Exposure + Aperture + Digital Gain

Select one of the four modes in the *Auto Mode* drop down list.

The automatic exposure control compares the *Target Luma* value to a center weighted calculated luma value in the output image. Adjustments are made to the exposure, aperture and gain values to reach the target value. Use the edit box, up/down arrows or slider bar to adjust the *Target Luma*.

Use the minimum and maximum settings for exposure, gain and aperture to ensure that the parameter stays within the desired range.

To keep the exposure constant and vary only the digital gain use the *Auto Mode Exposure + Digital Gain* and set the minimum and maximum exposure to the same value. The same approach can be used to vary only the lens aperture by choosing *Auto Mode Exposure + Aperture*, and setting the minimum and maximum exposure settings to the same value.

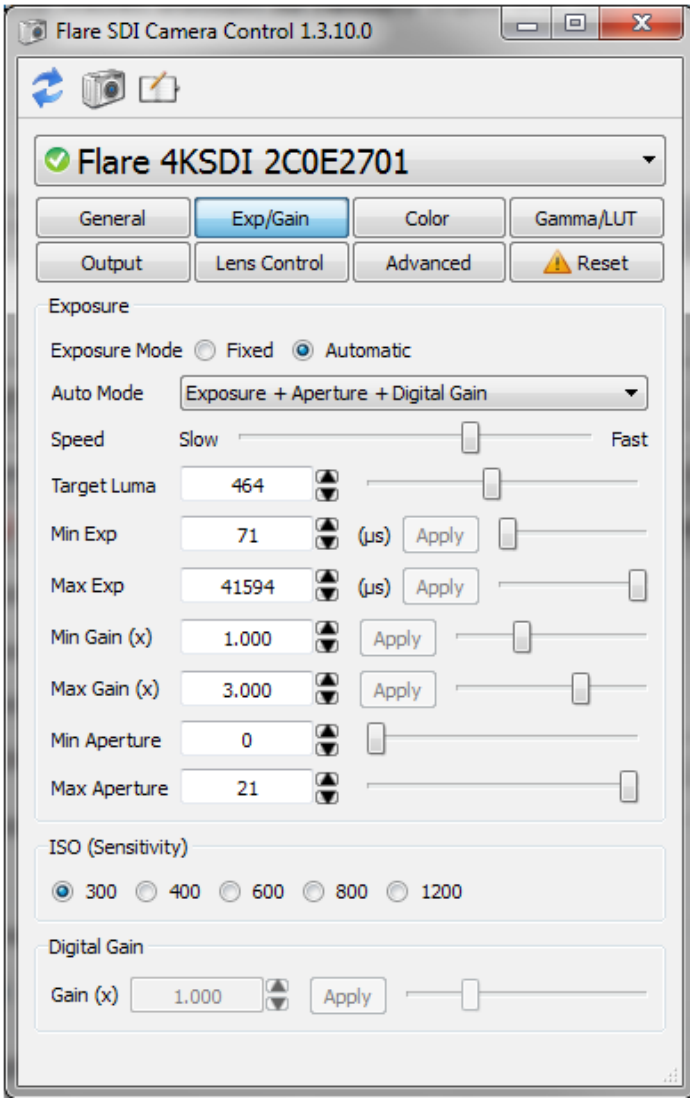

Figure 8. Automatic exposure mode

3.5.2 ISO (Sensitivity)

Use the radio buttons in the ISO section to set the camera sensitivity level. ISO 1200 is a +12dB increase from the native ISO 300 setting.

3.5.3 Digital Gain

The digital gain can be set up to 3.999x (or $3^{1023}/_{1024}$) using the *Gain (x)* edit box. The digital gain is set in step of 1/1024 ≈ 0.001. Negative gain can also be applied by setting the value less than 1.0 times.

3.6 Color View

The Color control view is shown in Figure 9, with Tracking White Balance selected.

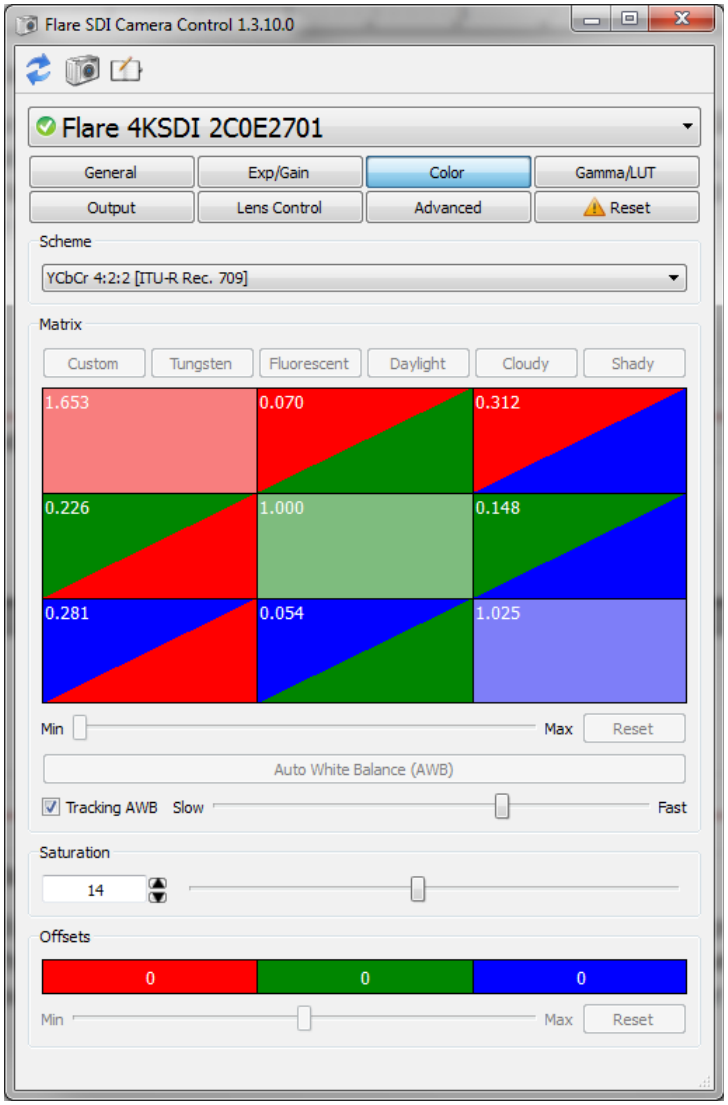

Figure 9. Color view

3.6.1 Scheme

The Flare 4KSDI supports both ITU-R BT.709 and ITU-R BT.2020 RGB to YCbCr conversion derivations. Use the *Scheme* drop down list to chose the output format used.

3.6.2 Color Matrix

The Flare 4KSDI has 5 color temperature presets: *Tungsten*, *Fluorescent*, *Daylight*, *Cloudy* and *Shady*. Press one of the buttons at the top of the *Matrix* section to select one of the presets. With a color preset selected the red, green and blue multipliers in the Color Correction Matrix (CCM) cannot be changed and will be greyed out. The *Auto White Balance (AWB)* and *Tracking AWB* features are also not available when a color preset is selected. To manually change the color multipliers or use the *AWB* or *Tracking AWB* features select the *Custom* button at the top of the *Matrix* section.

The CCM is used to compensate for cross-talk induced by the sensor micro-lenses and color filter process, lighting and temperature effects. The range of the multipliers in the 3x3 matrix is (-8, 7.999), in steps of 1/1024 ≈ 0.001. The matrix is shown in Figure 10.

$$\begin{bmatrix} R' \\ G' \\ B' \end{bmatrix} = \begin{bmatrix} Crr & Crg & Crb \\ Cgr & Cgg & Cgb \\ Cbr & Cbg & Cbb \end{bmatrix} x \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

Figure 10. Color matrix

Each of the nine elements are colored to easily identify the colors effected by the multiplier.

To change one of the multipliers first select the element in the matrix with a left mouse click. Selected element's value will be shown larger than the others. Use the slider bar below the matrix to adjust the selected multiplier. Press the *Reset* button to reset the selected element.

The identity elements (Crr, Cgg and Cbb) are used for white balance. These elements can be changed manually or press the *Auto White Balance* (AWB) button to perform an automatic color balance.

For continuous automatic white balance check the *Tracking AWB* checkbox. The tracking AWB uses the entire image to evaluate the color balance and updates are made to the identity CCM multipliers every second frame. The magnitude of the changes applied to the multipliers controls the speed and smoothness of the operation. Use the slider bar to adjust the speed of the color changes.

3.6.3 Saturation

The color saturation can be set from 0 to 30. A saturation setting of 10 produces no change, a

value of 0 produces a black and white image and values greater than 10 increase saturation with a value of 30 producing super color. To change the color saturation enter a value into the edit control box, or use the up/down arrows beside the edit box or use the slider bar.

3.6.4 Color Offsets

An offset can be applied to each color plane at the output of the CCM and saturation block within the color processing pipeline of the Flare 4KSDI camera. The range of the integer offset is (-512, 511). To change the offset value first select the color plane to adjust. Next use the slider bar to adjust the offset value. Press the *Reset* button to set the selected offset back to zero.

3.7 Gamma/LUT View

The Gamma/LUT control view is shown in Figure 11.

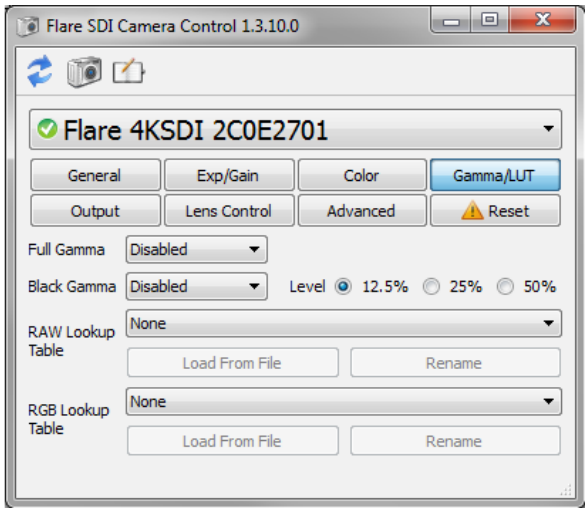

Figure 11. Gamma/LUT view

3.7.1 Full Gamma

There are 6 factory loaded Full Gamma tables in the Flare 4KSDI, ranging from 1.25 up to the ITU-R BT.709 Gamma transfer function. Also included in the Full Gamma tables is the popular IO Industries Film (IOI Film) transfer function.

Flare 4KSDI camera also has a black gamma option where only the lower pixel values are effected. Black tonal curve adjustments can be made using this feature. The blacks can be crushed to create a desired effect or can be raised to see more detail in the shadows of the scene. Eight lookup table values are stored in the camera corresponding to the following correction values N (using $Y = X^{1/N}$ function) :

{1/2.0, 1/1.75, 1/1.5, 1/1.25, 1.25, 1.5, 1.75 and 2.0}

Use the *Black Gamma* drop down list to choose the desired curve.

The pixel range effected by the black gamma LUT can be set to three different levels: 12.5% (10-bit pixel values in range 0-127), 25% (0-255) or 50% (0-511). Select one of the three *Level* radio buttons to set the desired range.

3.7.2 RAW Lookup Table

The Flare 4KSDI camera has a user LUT stage in the RAW data path. Up to four lookup tables can be saved to the camera. Select the lookup table to load by using the *RAW Lookup Table* drop down list.

Any of the four saved LUTs can be renamed. Select the LUT from the drop down list and then press *Rename*. A dialog will pop-up with an edit box to enter the new name. The name can be up to 32 characters long. Note that the on-screen menu will only display 16 characters when using the remote control. Press *OK* to save the name or *Cancel* to abort.

To load a RAW custom LUT into the camera first select the LUT to be overwritten from the *RAW Lookup Table* drop down list. Press the *Load From File* button. A file select/browse dialog will pop-up to choose the file to load. The four LUT examples loaded into the Flare SDI cameras at the factory are stored in the Lut sub-folder in the installation path (..\IO Industries\Flare\Lut\). Figure 12 shows example notation of a .lut file, which can be edited using any text editor such as Notepad or Wordpad.

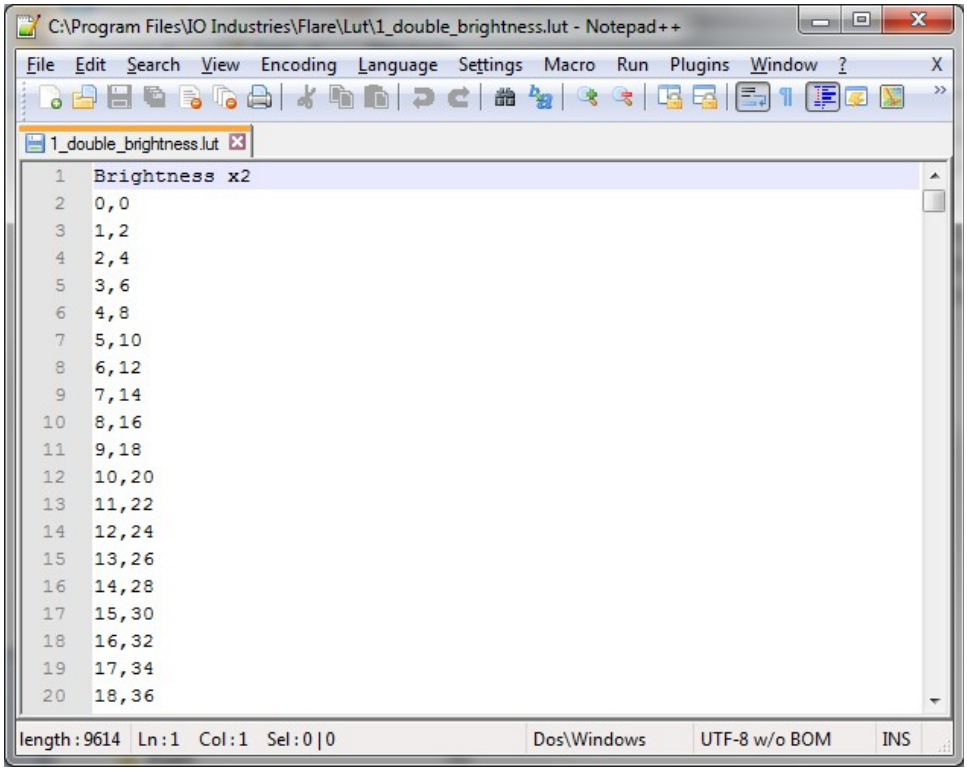

Figure 12. Example .lut file notation

3.7.3 RGB Lookup Table

The Flare 4KSDI has a user RGB LUT stage in the color data path. Up to six lookup tables can be saved to the camera. Select the lookup table to load by using the *RGB Lookup Table* drop down list. Follow the same procedure as the RAW Lookup Table to load from file and rename. Figure 13 shows the notation of the RGB .lut file. The first column in an RGB .lut file contains the color plane designation.

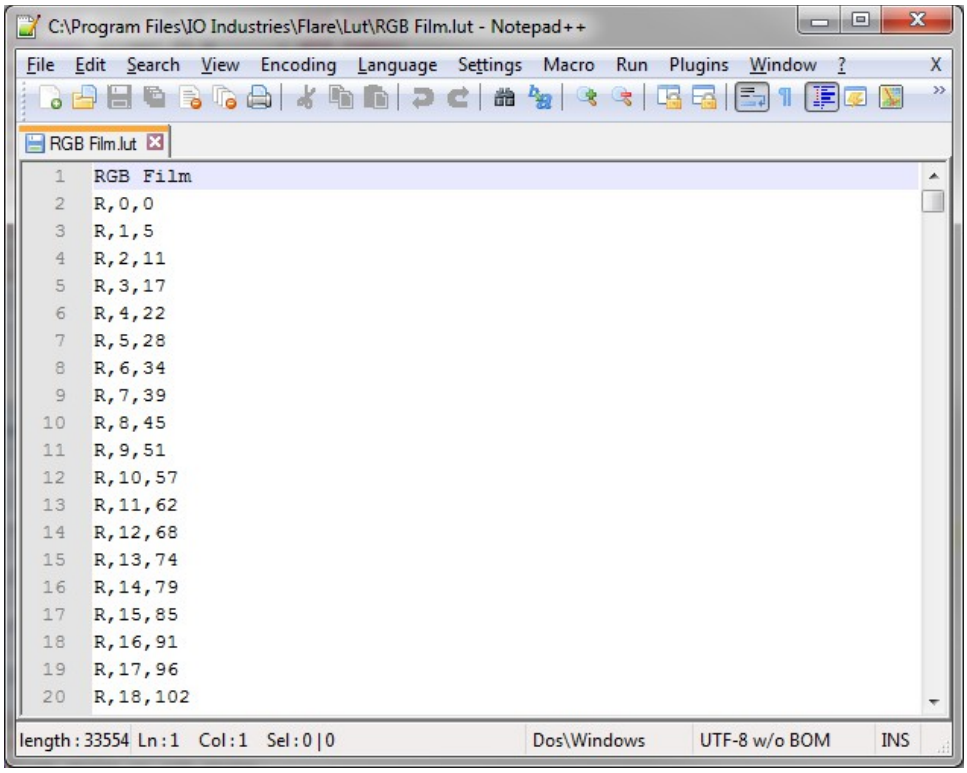

Figure 13. Example RGB .lut file notation

3.8 Output View

The Output control view is shown in Figure 14.

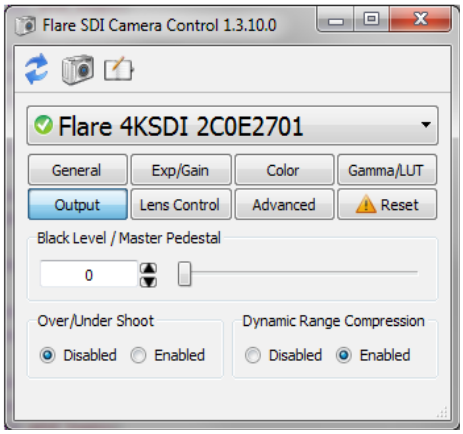

Figure 14. Output view

3.8.1 Black Level / Master Pedestal

Use the slider bar or edit box in the *Black Level / Master Pedestal* section to set the output master pedestal.

3.8.2 Over/Under Shoot

By default the Flare 4KSDI cameras are set to legal output ranges according to SMPTE 274M section 8.7. These ranges are 64-940 for Luma (Y) and 64-960 for Chroma (Cr and Cb), for 10-bit outputs. To enable overshoot/undershoot output range select the *Enabled* radio button in the *Over/Under Shoot* section. The output range is 4-1019 for both Luma and Chroma with overshoot/undershoot enabled, in accordance with SMPTE 274M section 8.12.

3.8.3 Dynamic Range Compression

Dynamic range compression is used during the color space conversion from RGB to YCbCr to ensure the output values are within the expected range. Select the *Disabled* checkbox in the *Dynamic Range Compression* section to bypass the compression block. With the compression disabled the dynamic range of the scene increases, while the contrast decreases.

3.9 Lens Control View

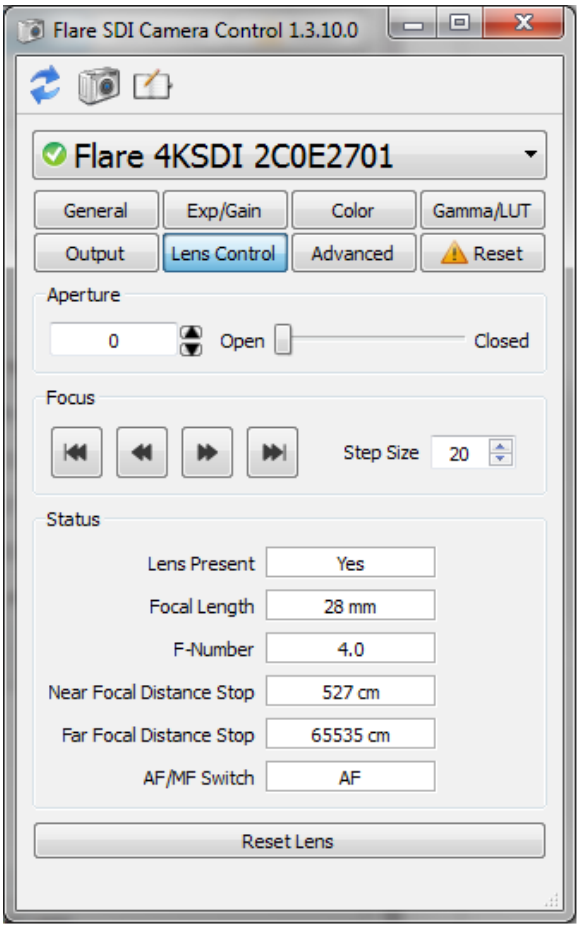

Figure 15. Lens Control view

The Lens Control view is shown in Figure 15.

3.9.1 Aperture

The aperture setting controls the iris in the lens to vary the amount of light it allows into the camera. An aperture value of zero corresponds to a fully open aperture. The maximum number of aperture steps varies from lens to lens.

3.9.2 Focus

The large arrow buttons are used to change the focus position of the lens. From left to right, the button functions are: move focus to minimum, step focus towards minimum, step focus towards infinity and move focus to infinity. The *Step Size* adjustment controls how far the lens moves with each press of the step arrows. The effect of the step size can vary from lens to lens.

3.9.3 Status

Information about the current state of the lens is displayed in the status area. Any value that the lens does not report to the camera will be displayed as zero. If an EF lens is not connected to the camera, the *Lens Present* box will be empty and all controls on this page will be greyed-out.

Press the *Reset Lens* button to reset the lens controller.

3.10 Advanded View

The Advanced control view is shown in Figure 16.

The *Horizontal Line* and *Bad Pixel* correction algorithms should not be disabled. For more information contact IO Industries Inc.

The *Anti-Flicker* correction block reduces the small difference in sequential frames from the sensor generally only visible with high gain or gamma encoding. This feature is not intended to correct for flicker from a light source.

The *Random Row Correction* algorithm reduces the random row noise from the sensor readout. When enabled columns 1-8 and 4089-4096 are electrically dark giving a reference for the noise and used in the correction algorithm. In a 4K output mode these columns will be black. In an UHD output mode the 3840 columns used are centered on the sensor, so the electrially dark columns are not visible in the output image.

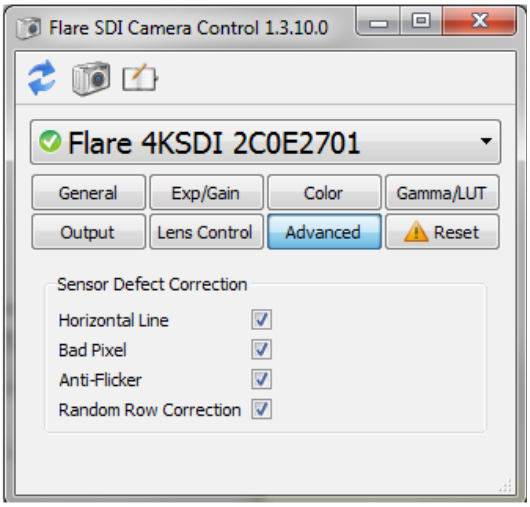

Figure 16. Advanced view

4 Firmware Update Utility

The FPGA firmware in a Flare 4KSDI camera can be updated using a USB to RS-485 adapter connected to a PC running 32-bit or 64-bit Windows (XP/2000/Vista/Win7) operating system. Non-volatile memory is used to store the FPGA firmware in the Flare 4KSDI cameras. If power to the camera is lost during the update process, or power is cycled on a camera after an unsuccessful update, the camera will no longer function and will have to be returned to IO Industries for programming, at the expense of the customer. Please contact IO Industries if a firmware update is required. Figure 17 shows the firmware update utility, flare_isp.exe.

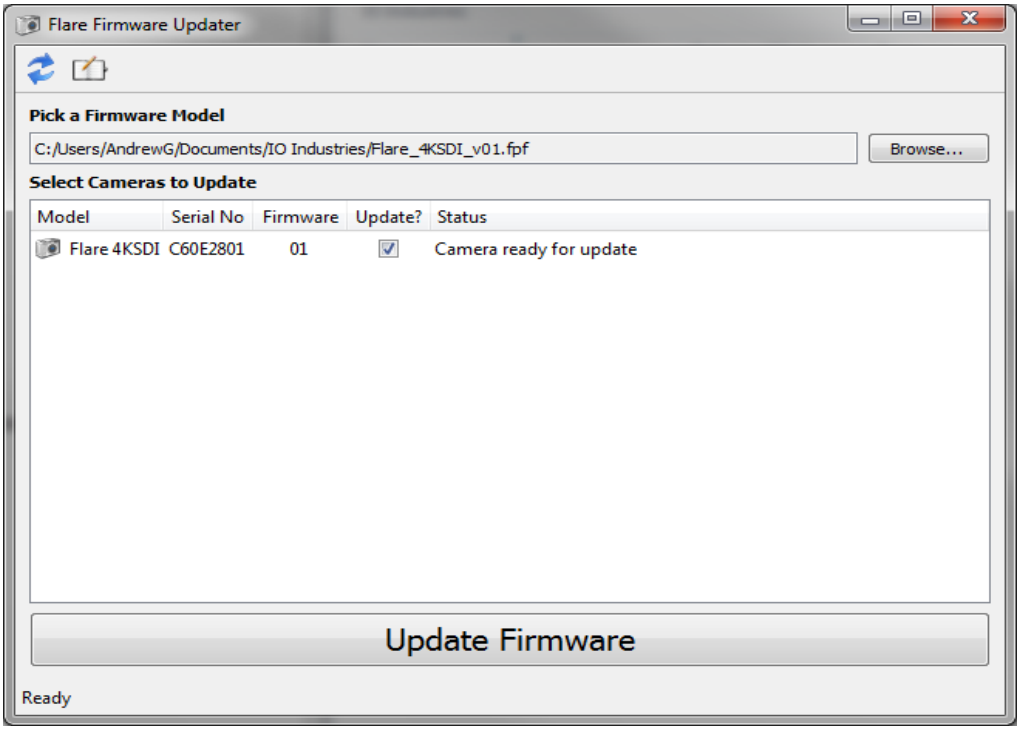

Figure 17. Firmware update utility

The utility will list all cameras found in a system. It is possible to program multiple cameras at the same time, however they must be the same type. Select the file to program using the *Browse* button. Check the *Update?* checkbox beside the camera to update. Finally press *Update Firmware*. This operation may take over twenty minutes to complete, do not shut down the application or cycle power on the camera while the operation is in progress. The progress of the operation is shown on the status line for each camera.

5 Sensor Specifications

Specification	4KSDI
Sensor	CMOSIS CMV2000-2E5C1PA
Effective Pixels	4096 x 3072
Optical Format	Super 35mm with 2160 lines
Pixel Pitch	5.5 x 5.5 μm^2
Full Well Charge	13.5 Ke-
Conversion Gain	0.075 LSB/e-
Temporal Noise	13 e-
Dynamic Range	12 stops
ISO Rating	300
Sensitivity	4.64 V/lux.s
Parasitic Light Sensitivity	< 1/50000
Fill Factor	> 50% (with micro lenses)
Quantum Efficiency	> 50% @ 550nm (with micro lenses)

Table 6. Sensor specifications

6 Spectral Responses

A typical spectral response for Flare 4KSDI is shown in Figure 18.

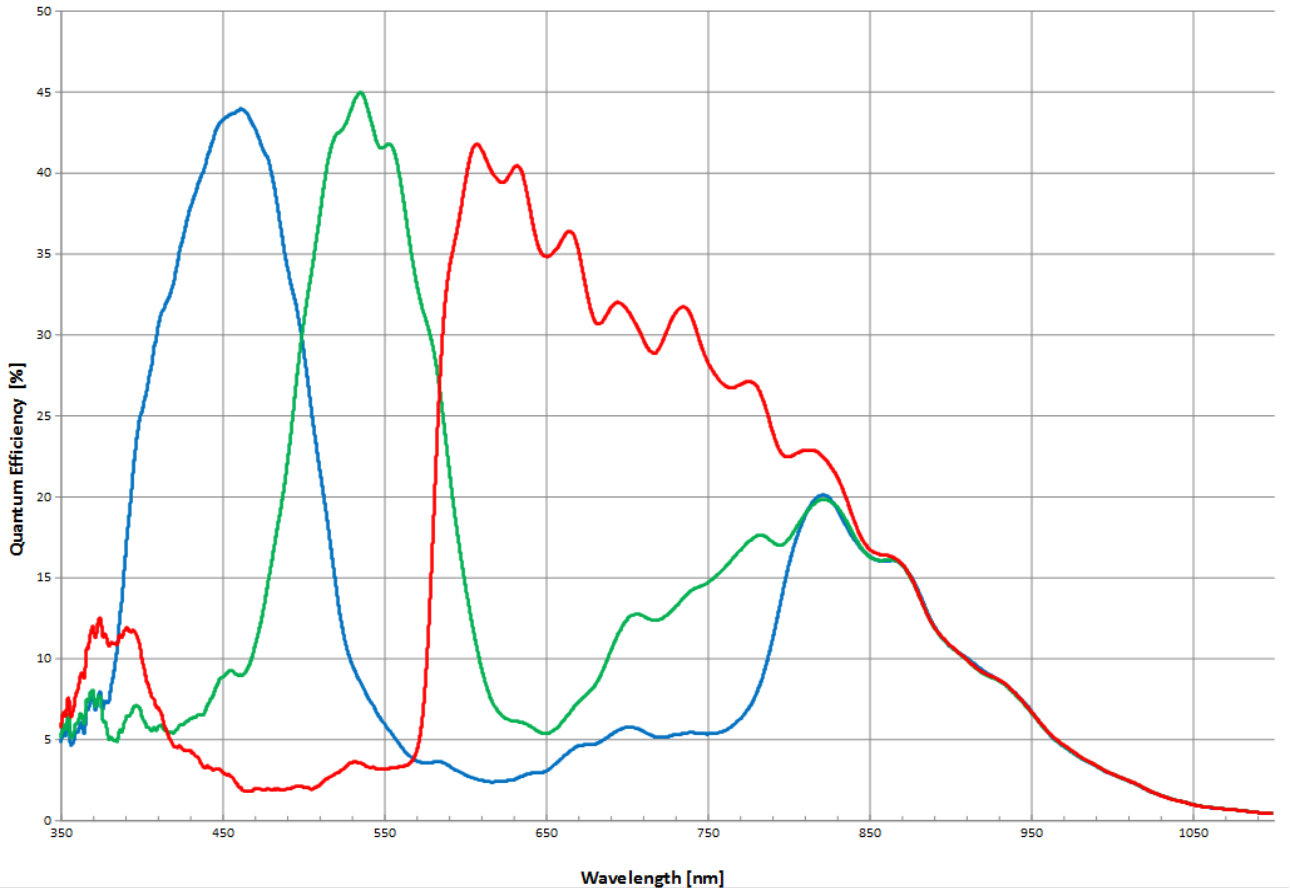

Figure 18. Color Spectral Response

7 Mechanical

Camera housings are made with high precision from machined aluminum. Mechanical drawings are shown in Figure 19.

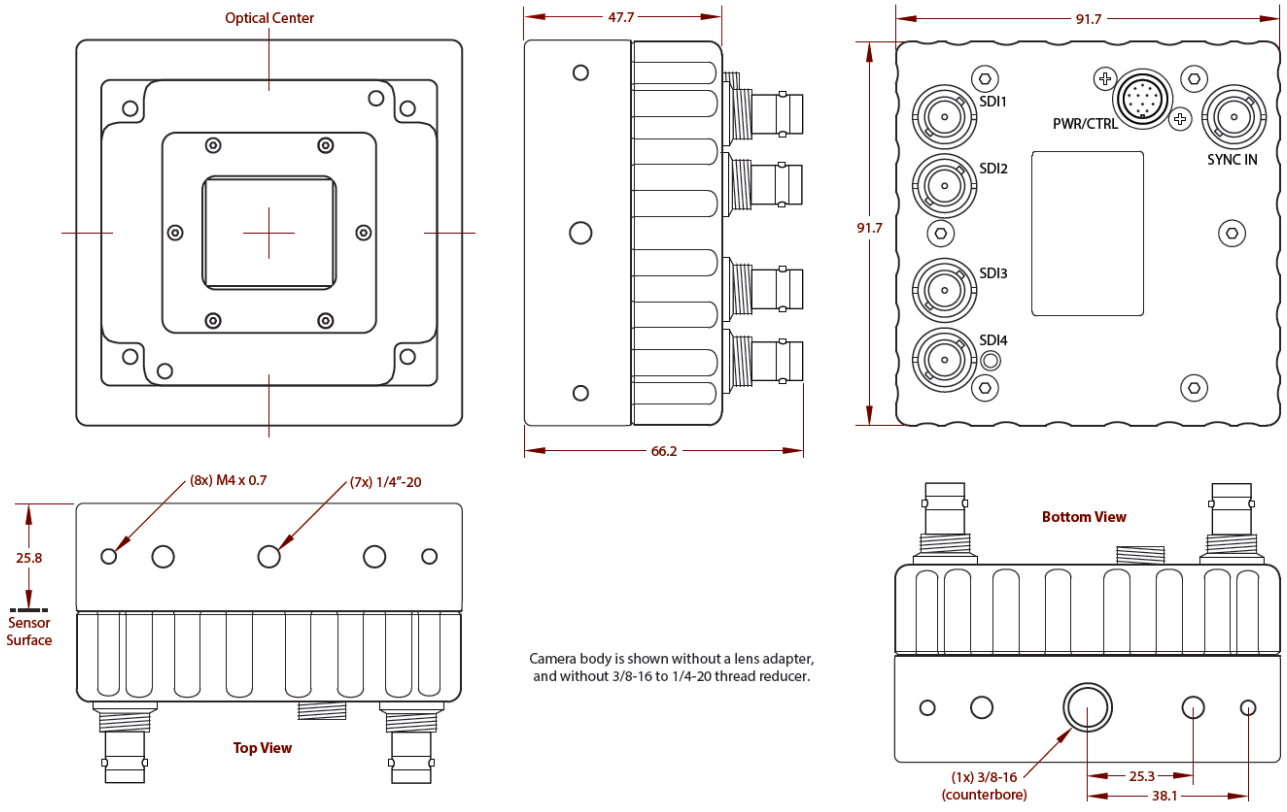

Figure 19. Mechanical Drawings

7.1 Mechanical Specifications

Summary of mechanical specifications are shown in Table 7. Mounting holes on all sides of the camera provides many mounting options.

Specification	Description
Size	91.7 mm x 91.7 mm x 47.7 mm
Weight	0.74 kg (with no lens or mount)
Mounting Holes	Bottom: 1x 3/8”-16, 2x 1/4”-20, 2x M4x0.7 Top: 3x 1/4”-20, 2x M4x0.7 Sides: 1x 1/4”-20, 2x M4x0.7
Power Connector	12-pin threaded Hirose Mating connector part # HR10A-10TPA-12S(73)
Video Output	4 x standard BNC
Sync Input	1 x standard BNC

Table 7. Mechanical specifications

7.2 Power

Flare 4KSDI cameras are powered using a 7-19V DC power source. The power connector is shown in Figure 20, and the pinout is shown in Table 8.

Caution must be taken when using non-smart batteries and the voltage is running near the minimum of the camera, power cycling and over-discharge of the battery may occur.

When using the active EF lens mount the power supply range must be 11-19V DC.

Pin	Description	Pin	Description
1	NC	7	RS232-IN (lens control)
2	RS485+	8	NC
3	7-19 V	9	RS485-
4	7-19 V	10	NC
5	GND	11	RS232-OUT (lens control)
6	GND	12	NC

Table 8. Power connector pinout

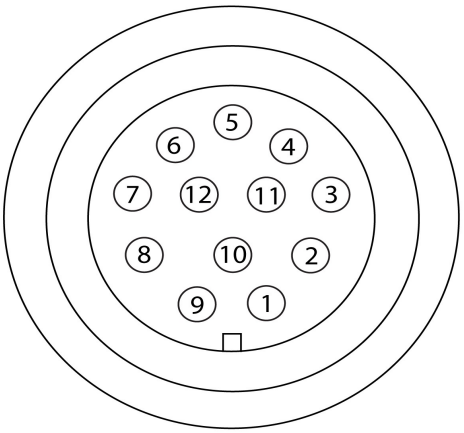

Figure 20. Power Connector

7.3 LED Status Indicator

A tri-color (orange/green/red) LED on the back of the camera is used to indicate operational status. Table 9 summarizes the operating states indicated by the LED. When using a tri-level sync reference the LED also provides status information.

LED State	Description
Orange	Camera is initializing (~ 5-6 seconds after power is applied).
Green	Camera is operational and functioning correctly. Sync enabled, tri-level input detected and camera output is currently line and frame locked[2].
Fast flashing green 30ms on / 30 ms off	Executing long command.
Flashing red	Error accessing user set memory.
Red	Fatal error.
Slow flashing green 970ms on / 30ms off	Sync enabled, no tri-level input detected.
Slow flashing green and orange 970ms green / 30ms orange	Sync enabled, tri-level input detected and camera output is currently line locked[1].

Table 9. LED status

1. *Line locked is when the camera's output horizontal sync matches the period of the tri-level sync reference horizontal sync .*

2. *Frame locked is when the camera's output vertical sync is in phase with the tri-level sync reference vertical sync.*

8 Camera Commands

For advanced users, control of a Flare 4KSDI camera can be done using a terminal program or control can be incorporated into a custom user interface or application using the simple ASCII command protocol. Below are some key points about the serial control:

- 8-bit, 115200 baud, 1 stop bit and no parity.
- All sent commands end with a carriage return (0Dh), which can also be sent at any time to reset the uart receiver state machine within the camera and return it to an idle/ready state.
- Commands are 3 ASCII characters followed by the setting or simply a carriage return when no settings are associated with the command.
- A space is sent between the command and the setting.
- All settings are in hexadecimal.
- All commands letters are in lower case (including settings hex values a-f).
- To query a command a carriage return is sent after the last command character.
- Successful commands return ACK (06h, generally seen as a dash (-) in terminal programs), invalid or rejected commands return NAK (15h, generally seen as plus sign (+) in terminal programs). Note: some terminal programs do not display non-printable characters such as ACK and NAK.
- A query returns the command, the current value, the minimum and maximum allowable values within brackets, a carriage return and finally an ACK.
- Get camera parameters command (**gcp**) returns all command settings.
- Help command (**hlp**) returns list of all available commands and brief description.

Examples:

1 - Set primary exposure time to 10ms (in microseconds = 10000 or 0x2710)

Command: **ex1 2710<CR>**
Response: **<ACK>**

2 - Query primary exposure time:

Command: **ex1<CR>**
Response: **ex1 2710 (0047,a267)<CR>**
<ACK>

8.1 Command Summary

Table 10 summarizes all available commands. The presence and size of a command's parameters are shown with the letter 'Y' (see *Format* column). Each letter 'Y' represents a hexadecimal digit from 0 to f.

Command	Format	Description	Notes
Video Format	**vid YY**	Video output format	00 – UHD 23.98Hz 01 – UHD 24Hz 02 – UHD 25Hz 03 – UHD 29.97Hz 04 – UHD 30Hz 05 – UHD 50Hz 06 – UHD 59.94Hz 07 – UHD 60Hz 08 – 4K 23.98Hz 09 – 4K 24Hz 0a – 4K 25Hz 0b – 4K 29.97Hz 0c – 4K 30Hz 0d – 4K 47.95Hz 0e – 4K 48Hz 0f – 4K 50Hz 10 – 4K 59.94Hz 11 – 4K 60Hz All output modes are 10-bit per pixel. Changing video format overrides other settings (sam, dul). On the format change any conflicting setting will be reset.
Sampling Format	**sam Y**	Color sampling format	0 – 4:2:2 Y'Cb'Cr' 1 – 4:4:4 R'G'B', only available for video formats that are 30Hz or less, and quad link configuration.
Link Configuration	**dul Y**	Output link configuration	0 – Quad link 1 – Dual Link, must be in 4:2:2 sampling format.
Sensitivity	**iso Y**	Sensor Analog Gain	0 – 1x gain (native ISO 300) 1 – 4/3x gain (400) 2 – 2x gain (600) 3 – 3x gain (800) 4 – 4x gain (1200)
Pixel Interleaved	**pin Y**	2-sample pixel interleave mapping	0 – quadrant based mapping 1 – 2-sample pixel interleave mapping
Raw Output	**raw Y**	Output raw Bayer data	0 – Color (Y'Cb'Cr' or R'G'B') 1 – Raw Bayer pixel data

Command	Format	Description	Notes
Sync Enable	**syn Y**	Camera synchronization enable	0 – Disabled 1 – Enabled
Sync Detect	**syd**	Returns status of sync input	Return values: 0 – sync off or no sync signal present 1 – line locked 3 – line and frame locked
Sync Shift	**sys YYYY**	Shift output relative to sync input	- Range 0x0001-0x1fff. - Camera subtracts 1000h from parameter value for internal 2's complement number. - Range (-4095,4095). - Each count represents 1.896µs.
Color Matrix RR	**crr YYYY**	3x3 Color Correction Matrix (CCM) entry (1,1)	- Range 0x0001 – 0x3fff - Camera subtracts 0x2000 to make internal Signed 3.10 fixed point multiplier value. - Internal range (-8.0, 7.999) - Parameter value 0x2400 equals 1.0x gain. - Parameter value 0x2000 equals 0.0x gain.
Color Matrix RG	**crg YYYY**	CCM entry (1,2)	
Color Matrix RB	**crb YYYY**	CCM entry (1,3)	
Color Matrix GR	**cgr YYYY**	CCM entry (2,1)	
Color Matrix GG	**cgg YYYY**	CCM entry (2,2)	
Color Matrix GB	**cgb YYYY**	CCM entry (2,3)	
Color Matrix BR	**cbr YYYY**	CCM entry (3,1)	
Color Matrix BG	**cbg YYYY**	CCM entry (3,2)	
Color Matrix BB	**cbb YYYY**	CCM entry (3,3)	
Red Offset	**ofr YYY**	Red color offset	- Range 0x000 to 0x3ff. - Camera subtracts 0x200 from parameter value for internal 2's complement value. - Range (-512, 511). - Default (no offset) = 0x200.
Green Offset	**ofg YYY**	Green color offset	
Blue Offset	**ofb YYY**	Blue color offset	
Color Saturation	**sat YY**	Color saturation	- Range 0x00 and 0x1e. - Represents values of 0.0 (BW) to 3.0 (Super Color), increments of 0.1, for K parameter in color saturation matrix. - Default (no change) = 0x0a

Command	Format	Description	Notes
Full Image Gamma	**fgm Y**	Full image gamma Lookup Table (LUT)	- Normalized input to function $Y=X^{1/N}$. 0 – off (no change) 1 – N = 1.25 2 – N = 1.5 3 – N = 1.75 4 – N = 2.0 5 – ITU-R BT.709 Gamma transfer function: V' = 4.5V, V≤ 0.018 V' = $1.099V^{0.45}$ - 0.099, V > 0.018 *6 – IOI Film – Removed in firmware version 0x0b and higher.*
Black Gamma	**bgm Y**	Black gamma LUT	- Normalized input to function $Y=X^{1/N}$. 0 – off (no change) 1 – N = 1/2.0 2 – N = 1/1.75 3 – N = 1/1.5 4 – N = 1/1.25 5 – N = 1.25 6 – N = 1.5 7 – N = 1.75 8 – N = 2.0
Black Gamma Level	**bgl Y**	Percentage of pixels values affected by black gamma LUT	0 – 12.5% (0-127 in 10-bit pixel range) 1 – 25% (0-255) 2 – 50% (0-511)
RAW Custom LUT	**lut Y**	Enable custom LUT	- 12-bit LUT in raw data path (10-bit .lut file interpolated to 12-bit on load). - Up to 4 custom LUTs saved to non-volatile memory. 0 – off (no change) 1 – Use LUT 1 2 – Use LUT 2 3 – Use LUT 3 4 – Use LUT 4
RGB Custom LUT	**rgl Y**	Enable RGB custom LUT	10-bit RGB LUT (different table for each color plane). - Up to 6 custom LUTs saved to non-volatile memory. 0 – off (no change) 1 – Use RGB LUT 1 2 – Use RGB LUT 2 3 – Use RGB LUT 3 4 – Use RGB LUT 4 5 – Use RGB LUT 5 6 – Use RGB LUT 6
Primary Exposure Time	**ex1 YYYY**	Primary exposure time in microseconds	Primary exposure time in microseconds.

Command	Format	Description	Notes
Exposure Display	**exd Y**	Exposure display format for On-Screen Display	0 – Degrees 1 – Microseconds
Master Pedestal	**mpd YY**	Output black level (master pedestal)	- Range 0x00 to 0x7F. - Value added to RGB pixels values prior to Y'Cb'Cr' color conversion.
Overshoot	**ovr Y**	Output overshoot/undershoot enable	0 – off, legal output (SMPTE 274M 8.7) Y range 64-940. Cb and Cr range 64-960. 1 – on, extended output (SMPTE 274M 8.12) Y, Cb and Cr range 4-1019.
Dynamic Range Compression Disable	**ndr Y**	Disable dynamic range compression block in color conversion	0 – Range compression enabled 1 – Range compression disabled
Digital Gain	**dgn YYY**	Digital gain applied to sensor input up to 4x	- Parameter range 0x001 – 0xfff (0.00098 – 3.99902). - 2.10 fixed point multiplier. - Parameter value of 0x400 equals 1.0x gain.
Lens Aperture	**ape YY**	Set lens aperture	- Parameter range varies from lens to lens - 0 corresponds to a fully open aperture
Lens Focus Step	**fst YY**	Set focus step size	- Parameter range 0x04 to 0xC8 - Effect of step size varies from lens to lens
Lens Focus to Infinity	**fci**	Set lens focus to infinity	- Moves lens focus to infinity position
Lens Focus to Zero	**fcz**	Set lens focus to minimum	- Moves the lens focus to its minumum position
Lens Focus Step Infinity	**fsi**	Step lens focus towards infinity	- Steps the lens focus towards infinity using the current focus step size
Lens Focus Step Zero	**fsz**	Step lens focus towards minimum	- Steps the lens focus towards the minimum position using the current focus step size
Lens Reset	**lnr**	Reset EF lens control	
Lens Status	**lns Y**	Report lens status	0 – Lens ready (0 - no lens, 1 - lens ready) 1 – Focal length in mm 2 – F-number x 10 (eg. 41 = F4.1) 3 – Near focal distance stop in cm 4 – Far focal distance stop in cm Focal distance stop of 65535 means infinity 5 – Auto/Manual focus switch position (0 - AF, 1 - MF) Focus commands will not work if switch is in MF position

Command	Format	Description	Notes
Lens Control Bypass	**lcb Y**	Directly communicate with lens adapter	1 – enable bypass 0 – return lens control to camera - Enabling lens control bypass connects the serial interface directly to the lens adapter at the baud rate specified by lbr command.
Lens Baud Rate	**lbr Y**	Set RS232 baud rate to lens adapter	0 – 9600 1 – 14400 2 – 19200 (default) 3 – 38400 4 – 57600 5 – 115200 NOTE: the EF lens adapters are set to 19200 during production.
Auto Focus	**afc Y**	Auto focus using EF lens adapter	0 – Scan full focus range for highest contrast. 1 – Stop at first high contrast position.
Serial Baud Rate	**sbd Y**	Set RS485 baud rate	0 – 115200 1 – 460800 2 – 921600
Top Offset	**tof YYY**	Odd line sensor offset	- Factory calibrated advanced sensor option. Not recommended to change.
Bottom Offset	**bof YYY**	Even line sensor offset	- Factory calibrated advanced sensor option. Not recommended to change.
ADC Ramp	**adc YY**	ADC Ramp	- Factory calibrated advanced sensor option. Not recommended to change.
ADC Ramp Voltage 1	**rv1 YY**	ADC Ramp Voltage 1	- Factory calibrated advanced sensor option. Not recommended to change.
DC Ramp Voltage 2	**rv2 YY**	ADC Ramp Voltage 2	- Factory calibrated advanced sensor option. Not recommended to change.
Sensor Black Level	**blk YY**	Sensor black level	- Factory calibrated advanced setting. Not recommended to change.
Sensor Clip Level	**clp YY**	Sensor clip level	- Factory calibrated advanced setting. Not recommended to change.
Horizontal Line Correction	**hlc Y**	Horizontal line artifact correction	0 – off 1 – on
Bad Pixel Replacement	**bpx Y**	Bad pixel replacement algorithm	0 – off 1 – on
AEC Minimum Exposure	**amn YYYY**	AEC minimum exposure time	
AEC Maximum Exposure	**amx YYYY**	AEC maximum exposure time	
AEC Target	**aet YYY**	AEC target	- Target luma value for auto exposure control.

Command	Format	Description	Notes
AEC Minimum Gain	**adn YYY**	AEC minimum digital gain	
AEC Maximum Gain	**adx YYY**	AEC maximum digital gain	
AEC Minimum Aperture	**aan YY**	AEC minimum lens aperture	
AEC Maximum Aperture	**aax YY**	AEC maximum lens aperature	
AEC	**aex Y**	Auto exposure and gain control	0 – off 1 – auto exposure 2 – auto exposure and digital gain 3 – auto exposure and aperture 4 – auto exposure, aperture, and digital gain
AEC Speed	**aes Y**	AEC speed control	- Adjusts AEC reaction and settling times. - Parameter range 0 (slowest) to 3 (fastest). - Default 2.
Tracking Auto White Balance	**twb Y**	Tracking Auto White Balance	- Looks at entire image, updates every second frame. 0 – off 1 – on
Tracking AWB Speed	**tws Y**	Tracking AWB adjustment speed	- Adjusts the size of multiplier changes. - Parameter range 0 (slowest) to 3 (fastest). - Default 2.
Column FPN/PRNU Correction	**cfn Y**	Column fixed pattern noise correction	0 – off 1 – on
Row FPN/PRNU Correction	**rfn Y**	Row fixed pattern noise correction	0 – off 1 – on
Random Row Correction	**rrc Y**	Random row noise correction	0 – off 1 – on Note that the first and last 8 columns in the 4096 column image are replaced with black electrical reference columns used for the correction.
Pulsating Correction	**plc Y**	Reduce sensor pulsating/flicker	0 – off 1 – on
Desaturate Whites	**dst Y**	Desaturate color in whites near sensor saturation	0 – off 1 – on
YCbCr Conversion	**itu Y**	RGB to YCbCr conversion	0 – ITU-R BT.709 1 – ITU-R BT.2020

Command	Format	Description	Notes
Exposure Offset	**feo YYYY**	Exposure offset correction	- Range 0x0001 – 0x7FFF. - 8.7 fixed point value. - Factory calibrated value, not recommended to change.
Disable CCM Ancillary Packet	**dcm Y**	Disable CCM ancillary data packet insertion	0 – Enabled (packet inserted). 1 – Disabled.
Power-up Profile	**pup Y**	Camera power-up profile	- Sets one of 8 user profiles or factory default as the power-up configuration. - Parameter range 1h to Fh. - Value 1-8 sets user profile 1-8 respectively. - Values 9-Fh sets factory profile.
Auto White Balance	**awb**	Auto White Balance	- One shot auto white balance. - Changes identity values of color correction matrix (rr, gg, bb).
Camera Model	**cam**	Returns camera model	
Serial Number	**ser**	Returns camera serial number	
Firmware Version	**ver**	Returns FPGA firmware version	
Get Camera Parameters	**gcp**	Returns all current settings	- Returns all commands up to, and including **pup** command.
Help	**hlp**	Returns summary of all commands	
Reset Camera	**rst**	Complete camera reboot	- Loads from power-up profile.
Load Factory Settings	**fac**	Load from factory profile	
Save to User Set	**sav Y**	Save current settings to user set page	
Load from User Set	**lod Y**	Load settings from user set page	
Open User Set Name	**onm Y**	Open user set name for editing	
Write User Set Name	**wnm Y**	Write ASCII character to open user set	- Up to 32 characters per name
Save User Set Name	**snm**	Save currently opened user set name	
Read User Set Name	**rnm Y**	Read user set or LUT name	
Temperature	**tmp**	Internal camera temperature	Returns signed 7.8 fixed point 2's complement value.

Command	Format	Description	Notes
Color Presets	**cpr Y**	Color temperature presets	0 – Custom 1 – Tungsten (3200K) 2 – Fluorescent (4000K) 3 – Daylight (5500K) 4 – Cloudy (6000K) 5 – Shady (7000K)

Table 10. Command summary

8.2 Terminal Program in Windows

Terminal programs such as HyperTerminal, Tera Term or Realterm for Windows can be used to control a Flare 4KSDI camera using the ASCII commands shown in Table 11. In this section the setup and some examples are provided when using Tera Term, a free terminal emulator for Windows, to control the camera. The setup is similar on any other Windows based terminal program.

The serial port setup in Tera Term is shown in Figure 21.

Check the Windows Device Manager, under Ports (COM & LPT) heading to see which com port number the USB to RS-485 adapter has been assigned.

Set port settings to 115200 baud, 8-bit data, 1 stop bit, no parity and no flow control.

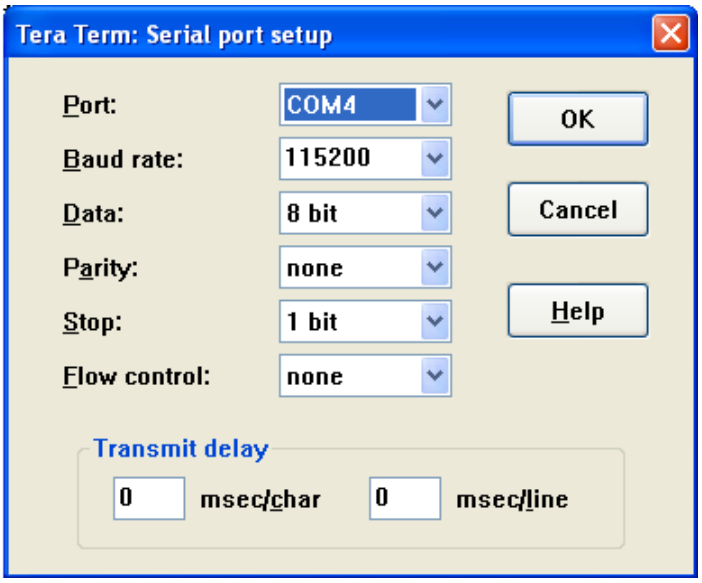

Figure 21. Serial port setup (Tera Term)

The terminal setup is shown in Figure 22.

- Enable Local echo.
- Set the New-line Receive option to CR+LF.
- Leave all other options as default.

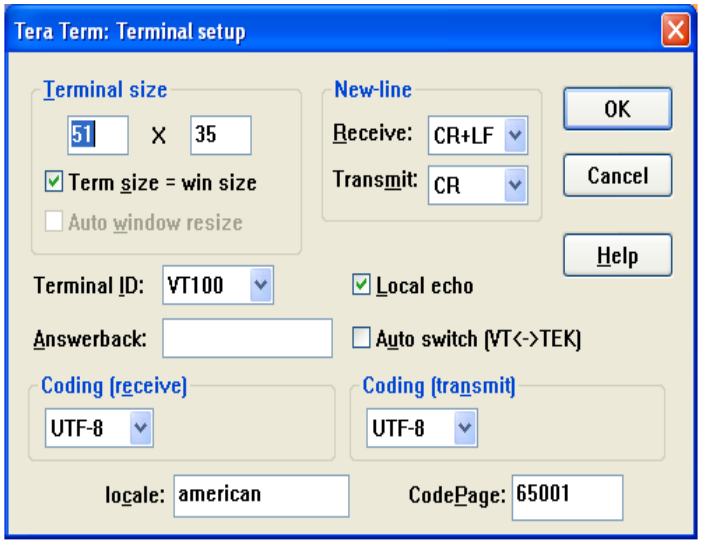

Figure 22. Terminal setup (Tera Term)

Note that Tera Term does not display non-printable characters such as ACK and NAK. Figure 23 shows an example of several commands being sent to the camera. In this example several command queries are sent (**cam**, **ver**, **ex1** and **vid**) followed by an Auto White Balance command (**awb**).

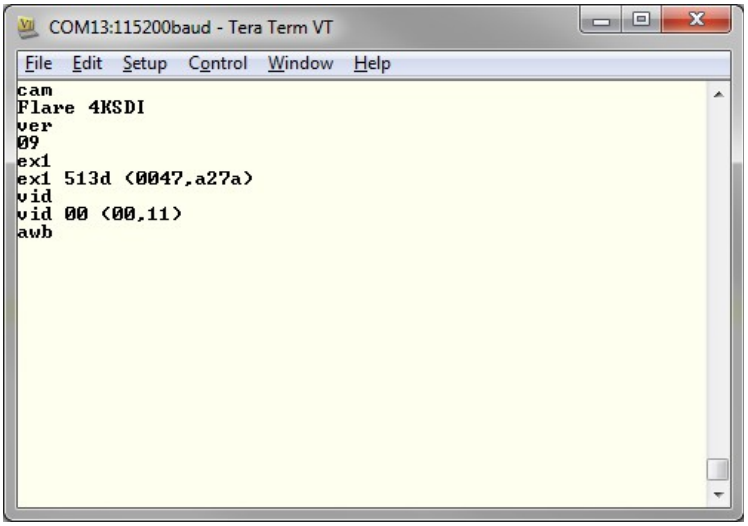

Figure 23. Example commands sent through terminal program

9 CCM Ancillary Packet

In firmware version 0x0d or higher the Flare 4KSDI inserts an ancillary data packet each frame containing the Color Correction Matrix (CCM) values. The values in the Color Correction Matrix (CCM) are Signed 3.10 fixed point numbers (2's complement) with the following bit assignments:

- Bit 13 – Sign
- Bits 12:10 – Integer portion
- Bits 9:0 – Decimal portion

The matrix elements are labeled as follows:

$$\begin{bmatrix} R' \\ G' \\ B' \end{bmatrix} = \begin{bmatrix} Crr & Crg & Crb \\ Cgr & Cgg & Cgb \\ Cbr & Cbg & Cbb \end{bmatrix} x \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

A Type 2 ancillary data packet including all nine matrix elements is inserted into the horizontal ancillary space (HANC) of line 12 in accordance with SMPTE 291M. The element values are padded to 16-bits (bits 15:14 = 00) and then split across two 10-bit words in the data packet, with the low byte sent first followed by the upper byte. The User Data Words are padded to 10-bit with 10b in bits 9:8 to avoid reserved code words.

The ancillary data packet is inserted in Data Stream #1 / Y channel only on all four output connectors.

A savable command, **dcm**, can be used to disable the insertion of the ancillary data packet if it causes problems with receiving equipment. Set **dcm 1** to disable the insertion. By default insertion is enabled, **dcm 0**.

The format of the Type 2 ancillary data packet is shown in Table 11.

Type	Data
ADF	0x000 0x3FF 0x3FF
DID	0x255
SDID	0x2AA
DC	0x212 (always 18 10-bit User Data Words)
UDW	Word 0 - “10” & Crr(7:0)
	Word 1 - “10” & “00” & Crr(13:8)
	Word 2 - “10” & Crg(7:0)
	Word 3 - “10” & “00” & Crg(13:8)
	Word 4 - “10” & Crb(7:0)
	Word 5 - “10” & “00” & Crb(13:8)
	Word 6 - “10” & Cgr(7:0)
	Word 7 - “10” & “00” & Cgr(13:8)
	Word 8 - “10” & Cgg(7:0)
	Word 9 - “10” & “00” & Cgg(13:8)
	Word 10 - “10” & Cgb(7:0)
	Word 11 - “10” & “00” & Cgb(13:8)
	Word 12 - “10” & Cbr(7:0)
	Word 13 - “10” & “00” & Cbr(13:8)
	Word 14 - “10” & Cbg(7:0)
	Word 15 - “10” & “00” & Cbg(13:8)
	Word 16 - “10” & Cbb(7:0)
	Word 17 - “10” & “00” & Cbb(13:8)
CS	Checksum

Table 11. CCM ancillary data packet structure.

10 Ordering Information

Figure 24 shows the parts included with the 4KSDI (P/N: 4KSDIKITxx-y).

Figure 24. Flare 4KSDI kit accessories

Figure 25 shows additional lens mounts.

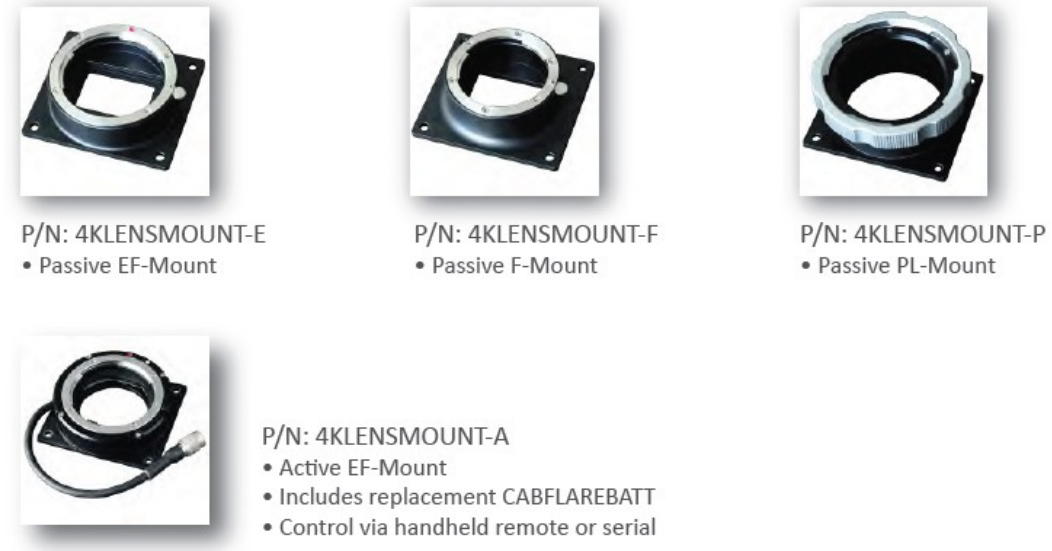

Figure 25. Lens mounts

Figure 26 shows the various cable accessories.

Figure 26. Cabling accessories

11 Document Revision History

Revision	Date	Modification
Preliminary – 2.0	--	Early adopter's release.
3.0	04/17/2015	General release.
3.1	04/28/2015	Added description of desaturate whites feature (***dst***), see Table 10.
3.2	05/15/2015	Update for firmware versions 0x0b and 0x0c. See firmware revision history for changes.
3.3	06/08/2015	Added description of ancillary data packet to report CCM values for each frame. See Section 9.
3.4	06/19/2015	Update for firmware version 0x0e. See firmware revision history for changes.

12 Firmware Revision History

Revision	Date	Modification
01-05	--	Early adopter's release.
06	03/12/2015	General release.
07	03/20/2015	***New Feature(s):*** - Tri-level sync.
08	04/01/2015	***Bug Fixes:*** - Two bad columns in 2SI image mapping and raw mode enabled. - Incorrect firmware version in on-screen menu.
09	04/10/2015	Change to flash write protect.
0a	04/28/2015	***Bug Fixes:*** - Sensor black level and clip values not set correctly when changing raw mode, or between image mapping modes (2SI and quadrant). ***New Feature(s):*** - Added color desaturation feature for whites near sensor saturation, see Table 10.
0b	04/30/2015	Removed last index from full gamma command (fgm), see Table 10. Set factory non-identity CCM values to zero.
0c	05/15/2015	***Bug Fixes:*** - Issue when switching to 50Hz frame rate (UHD or 4K) when current frame rate was 48Hz or less. Produced grey, nearly constant image.
0d	05/29/2015	***New Feature(s):*** - Added ancillary data packet to report CCM values for each frame. See Section 9.
0e	06/19/2015	***Bug Fixes:*** - Issue with auto aperture algorithm with fixed

Revision	Date	Modification
		exposure time, aperture setting would oscillate around target. - Speed control not working properly. ***New Feature(s):*** - Improved overall auto exposure, gain and aperture algorithm.